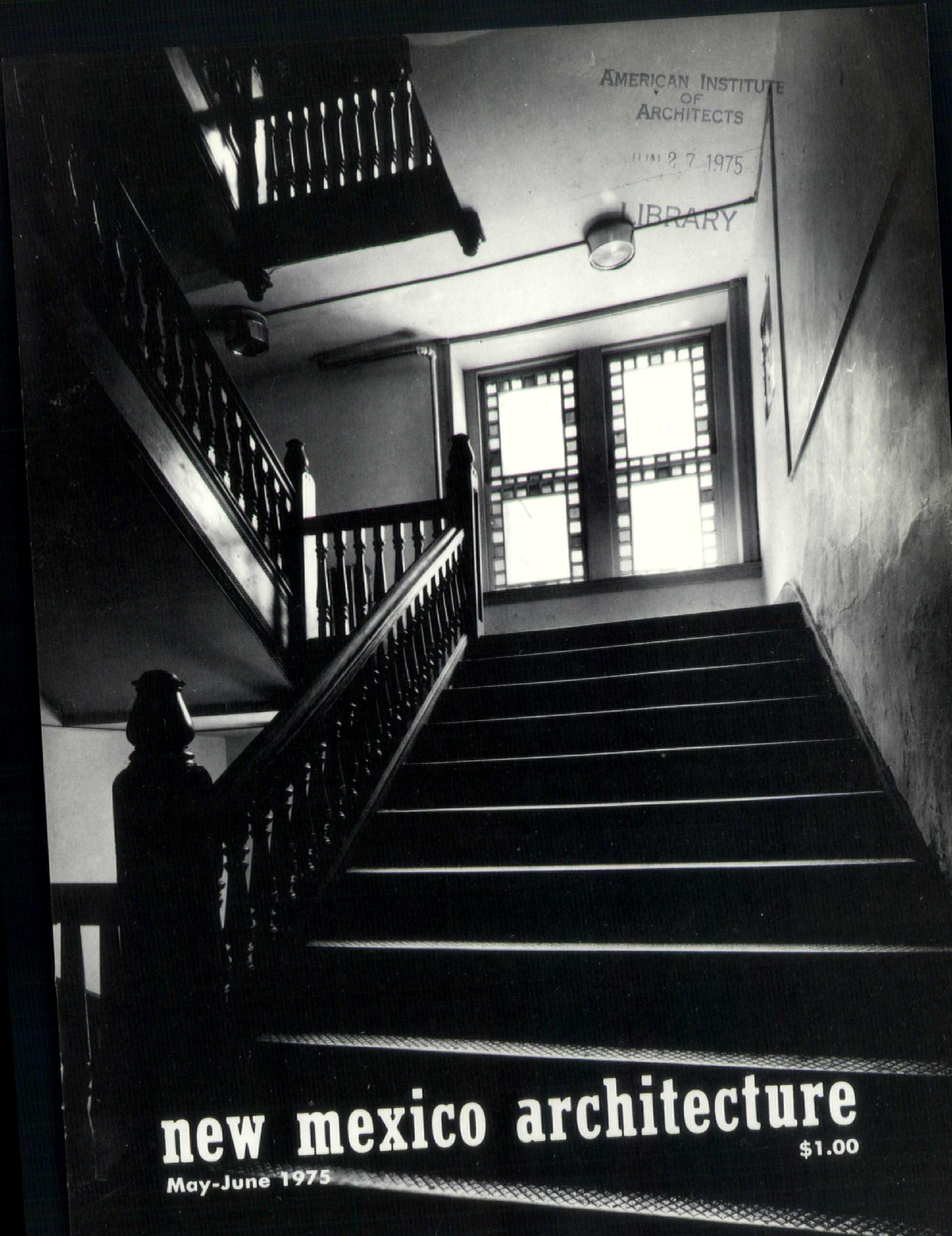

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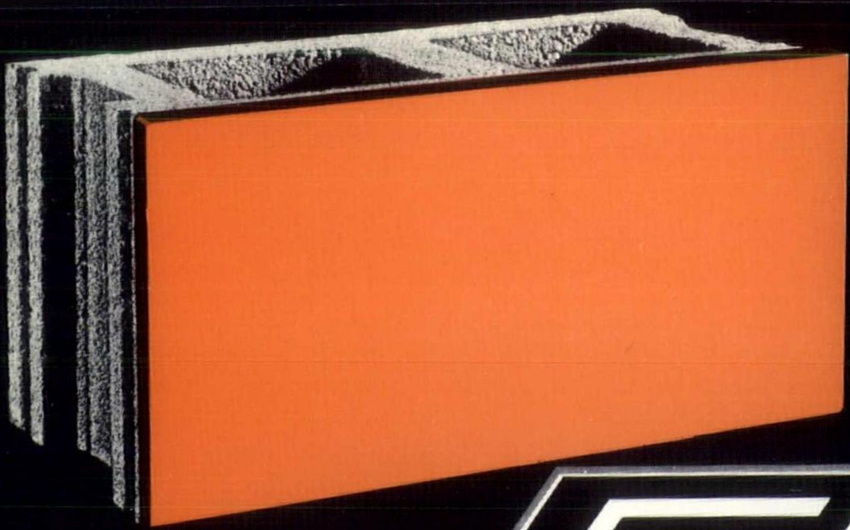

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IN THIS ISSUE

A letter to the editor is on page 9. It concerns the appointment of Stanley Hathaway, ex-governor of Wyoming, to be Secretary of the Interior. As we go to press it seems all too probable that our Senate will approve of Mr. Hathaway. Why, I cannot conceive, but then I too often find the Congress inconceivable. However, the letter is an important warning to us; we will have to keep a close, watchful eye on Mr. Hathaway.

□ □ □ □

Don't be misled by an ad in the Yellow Pages!

In the Santa Fe-Los Alamos telephone book released in March of this year is a totally misleading claim. In a large display advertisement on page 139 of the Yellow Pages, Richard M. Childers indicates that he is a member of certain organizations by inserting three sets of initials beneath his name. He thereby suggests that he is a corporate member of AID, the American Institute of Interior Designers, which he has never been, and a professional member of NSID, the National Society of Interior Designers, which he has never been. (Please see page 9 NMA, March-April 1975 which reports the merger of these two professional organizations into the American Society of Interior Designers, ASID).

Correspondence with the national headquarters of ASID advises me that no application for membership has been received from Mr. Childers.

I do not wish to imply that Mr. Childers is not capable in his chosen field. I only wish to point out to the readers of this magazine that to the best of my knowledge, Mr. Childers is not now, nor has he previously been, a member of AID, NSID. or ASID.

In the ad Mr. Childers also implies membership in SMDI; he may well be, but I do not know what is a SMDI. As President of the New Mexico Chapter of ASID, which encompasses all members of the former AID and NSID, and as editor of this magazine, which in the last issue published the roster of all current members of ASID, I feel that you the reader, should be informed of the advertisement; unfortunately, its deceptive message will be before all users of the Santa Fe - Los Alamos telephone book until March 1976.

So, watch out as your fingers go walking through the Yellow Pages.

—JPC

(Cover — Montezuma Hotel — Photographer — Robert Nugent)

—Official Publication of the New Mexico Society of Architects, A. I. A.—

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The Broadway Department store in Coronado Center in Albuquerque is now under construction using 8 foot twin tee prestressed concrete floor members totaling 115,600 square feet on two of the three floors. All columns and beams were also precast, prestressed concrete. Erection was accomplished in only four weeks working time.

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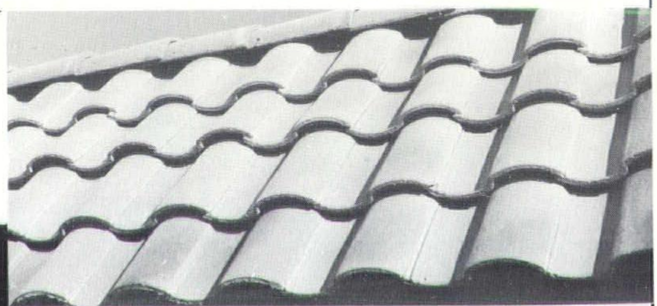

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MR. PRESIDENT,

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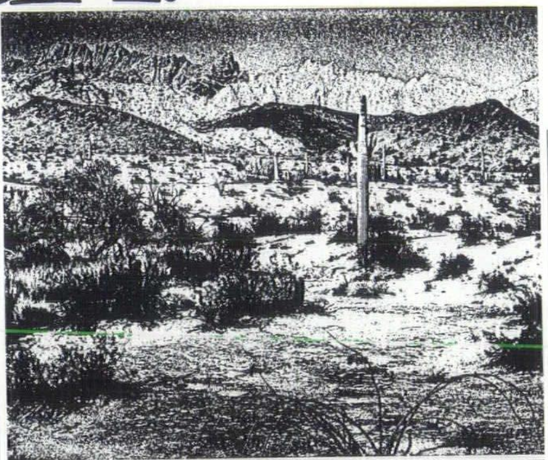
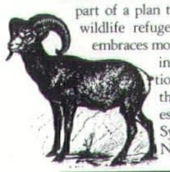
CIA?



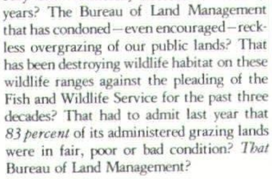
Or maybe the Coast Guard? Or the Social Security Administration? You haven't? Of course not. But your Secretary of the Interior may have. In fact, he has already started along such a course; hereafter more than two million acres of national wildlife refuge system lands in the West—three wildlife ranges established for the protection and management of wildlife habitat by President Roosevelt in the 1930s—will be managed exclusively by—not the FBI or Export-Import Bank—but by an agency just as ill-chosen: the Bureau of Land Management.

Kicked out in the process is the U.S. Fish and Wildlife Service, the one agency that has a mandate to manage federal wildlife habitat.

Mr. President, already the Secretary has recommended that BLM be given primary jurisdiction over two critically important wildlife areas in Alaska—the huge Noatak National Arctic Range and the Iliamna National Resource Range. Is all this part of a plan to dismantle our national wildlife refuge system—a system that embraces more than 30 million acres in 49 states? Will the national parks be next? What's this we hear about BLM establishing a *Natural* Park System to compete with the National Park System?

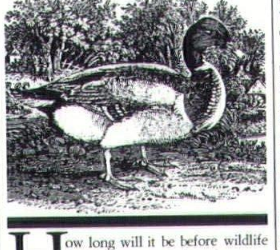


The Bureau of Land Management! Can it be true? The very same Bureau of Land Management that has been so cozy with commodity interests these many years? The Bureau of Land Management that has condoned—even encouraged—reckless overgrazing of our public lands? That has been destroying wildlife habitat on these wildlife ranges against the pleading of the Fish and Wildlife Service for the past three decades? That had to admit last year that *83 percent* of its administered grazing lands were in fair, poor or bad condition? *That* Bureau of Land Management?



Yes, *that* Bureau of Land Management. It's an outrage, Mr. President, and we ask you to overrule your Secretary of the Interior on this jurisdictional shift—*now,* before BLM can put its policies into effect.

What do the "wildlife experts" at BLM have in mind for the Kofa Game Range in Arizona (660,000 acres), the Charles Sheldon Antelope Range in Nevada (578,000 acres) and the Charles M. Russell Wildlife Range in Montana (970,000 acres)? They *say* they will continue to manage the areas primarily for wildlife use, but they're employing a term never before used in connection with wildlife refuge management: *multiple use.* The intent is clear, as is BLM's record elsewhere—using chemical herbicides, fencing and bulldozer-chaining of shrubs like pinyon juniper, all to remove native plants on which wild animals browse and to replace them with grass, on which livestock graze.



How long will it be before wildlife becomes one of the *other uses,* one of the afterthoughts, in this vast domain that once existed *primarily* as a home for America's dwindling populations of threatened wildlife species?

Mr. President, this nation has precious little habitat left for animals and birds which depend on natural conditions for survival—for example, the desert bighorn sheep, bald and golden eagles, the endangered peregrine and prairie falcons. We have paved, stripped, plowed and denuded most of it, first in our westward expansion and more recently in our shift from farm to city, our urban sprawl and our Great Obsession with the automobile. Therefore, what little we have left needs to be protected and managed primarily for its wildlife values.

Mr. President, we know there are some fine public servants in BLM, but this is an agency that is constantly badgered by higher-ups in government—yes, even by the White House—in the name of heavy-handed commodity interests. Grazing and mineral interests thus get its major attention. To many of its policy makers through the years wildlife has been an uneconomic nuisance without much of a constituency.

For thirty years BLM has been a deterrent to sound wildlife management on the big wildlife ranges in the West. Yet the Fish and Wildlife Service was always there to act as a restraining influence on the excesses of BLM. Wisely, Fish and Wildlife was given exclusive jurisdiction of the Desert Wildlife Range in Nevada in 1966, and recently the same agency was given the same undivided jurisdiction over the Cabeza Prieta Game Range in Arizona. But where the commodity interests have made themselves heard, the Secretary of the Interior has elected to give exclusive jurisdiction to an agency that knows little about wildlife management and *couldn't care less.*

All of this is to be accomplished, Mr. President, without even lip service to the National Environmental Policy Act, which requires a study of environmental impact when major federal actions affecting the environment are to be undertaken. How can this be?

Mr. President, the 100,000 members and contributors of The Wilderness Society call upon you to reverse your Secretary in this serious error. Now 40 years old, this organization has fought long and hard for the preservation of a significant portion of the remaining wilderness in this country—both for its importance to man and for the vital part it plays in sustaining wildlife populations. We believe it is vital that the public interest in the preservation of wildlife be placed higher on the scale of values than the short-term interest of a handful of western cattlemen and mining companies.

Please reverse the Secretary's decision and see that these wildlife ranges are assigned instead to the one agency that knows about wildlife and values its preservation—the U.S. Fish and Wildlife Service.

THE WILDERNESS SOCIETY

1901 Pennsylvania Ave., NW
Washington, DC 20006

Since 1935 The Wilderness Society has been the principal citizen organization working for the preservation of the vestiges of our great American wilderness.

Ads like this cost money. You can help. Send tax-deductible contributions to The Wilderness Society Wildlife Fund, 1901 Pennsylvania Ave., N.W., Washington, D.C. 20006. We'll be glad to send you, in turn, a free pamphlet, "Wildlife Needs Wilderness."

I received this letter from a concerned reader. Mrs. Untermyer maintained a home in Wyoming for several years before moving to Santa Fe.

Editor, New Mexico Architecture:

Among the numerous ill-advised actions taken by President Gerald Ford the appointment of the ex-governor of Wyoming, Stanley Hathaway, as Secretary of the Interior will possibly have in the long run the most lasting effect on the life of America.

As governor, Stanley Hathaway was a self-described promoter of industrial logging and mining development in Wyoming. He went on record as favoring the damming of the scenic, recreation rich upper Green River, flooding private lands and fishing areas and advocating an absurd diversion of the water from needed agricultural use to electric power plant cooling; he urged increased lumbering and clear cutting of timber on slow recovery national forest areas; he backed increased sale and leasing of Wyoming public lands for coal mining and oil shale development without due safeguards and with quite small returns to the state, thus creating a bonanza for coal and oil interests.

In order to create more jobs Governor Hathaway asserted that the natural resources of the state should not be left unused, even if the process of using them had results which adversely affected not only Wyoming, but adjoining states as well. To implement his ideas he has stated, in so many words, that if ecological balances were disturbed, environmental safeguards lowered or swept aside (although he denied they would be), wilderness areas invaded and wildlife habitats threatened, it was more important to create jobs in the state. This has proven to be something of a boomerang. In the process of development of coal, Rock Springs, and oil and minerals, Gillete, two good-sized "boom" towns have been created. Both have major water, sewage, housing and school problems for which no prior preparation or planning was done; apart from the acute housing and other ills, this has resulted in greatly increased crime and mental illness figures.

In almost all respects Hathaway has urged haphazard development of resources regardless of environmental and social impact; he has demonstrated little or no understanding of the long range consequences. He has consistently, and quite often scornfully, resisted the efforts of informed conservation organizations to establish and preserve wilderness areas and to protect public lands from exploitation.

To be sure, jobs are needed. But careful, thoughtful planning can create jobs and, at the same time, respect the environment. Natural resources can be used, but must not be abused or destroyed. The generations to follow should be able to live, enjoy and derive benefit from the natural resources of Wyoming. Thoughtless planning and development of the Hathaway type will present our children with a vast, but desolate landscape.

The Department of Interior is a hodge-podge of often contradictory agencies. It includes the Bureau of Reclamation, which likes to build dams wherever it can find a stream and which has a strong lobby at the Congress to insure jobs for itself. There is the Bureau of Land Management which is presently engaged in an effort to take over management of three large national game reserves and to gain control of proposed Alaskan National Parks and Wildlife Ranges. The Bureau has pursued a policy of "multiple use." *(See ad., page 8, opposite)* In the past this policy usually has meant use by mineral and grazing interests which have no interest in nor concern for ecological values. Further, the Bureau has allowed for energy exploitation and unregulated recreational use. All of this "multiple use" has resulted in considerable erosion damage and overgrazing.

In contrast is the National Park Service, which also is under the Department of Interior. According to the National Park Act, the Service is entrusted with the protection and preservation of some of our outstanding, unique and most beautiful areas throughout the country, although it is given very little money with which to carry out this purpose. It is supposed to allow park access to people in a number consistent with the preservation of those features for which the park was established. Hathaway says, as have others, "Parks are for people," and of course they are, but in this connection he strongly advocated the building of a jetport in Jackson Hole, Wyoming, which would have invaded Grand Teton National Park even more extensively than the present airport, because it would enable more people to come in more easily. In the face of a very strongly worded adverse impact statement, Hathaway urged the airport extension with apparently no conception of the probable consequences. It is unfortunate, but a fact, that too many people at one time using the parks means destruction of the parks, so that the people who follow us in time will have no parks, or at best, badly damaged ones.

The Secretary of the Interior is confronted with difficult and often conflicting problems and pressures; a well balanced and above all, informed judgement would seem to be a pre-requisite for the job. The past record of Stanley Hathaway hardly indicates that he possesses or can exercise such judgement. Unless, while in office, he radically changes his past attitudes, we can anticipate a rape of our public resources as those in Wyoming were raped.

Elise S. Untermyer, Santa Fe, N.M.

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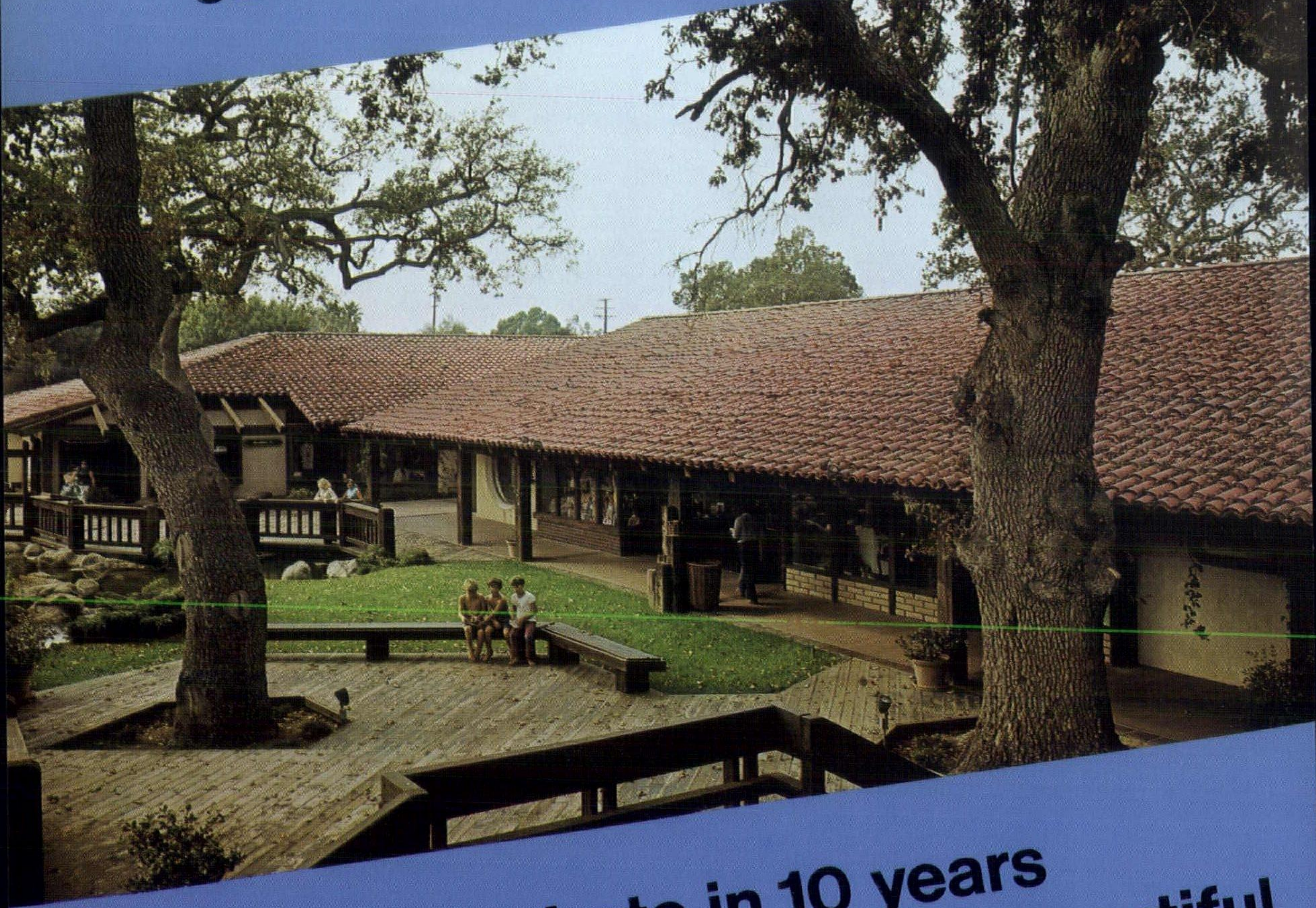

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SOLAR ENERGY & HOUSING—Part I, CLIMATIC ANALYSIS

prepared by The Architects, Taos

The intent of this report is to investigate a broad technique of climate analysis which will facilitate the indentification and evaluation of the *major* climatic parameters that affect building designs incorporating solar heating sub-systems, and to develop a graphical presentation of the analysis as it applies to the continental United States.

In searching the literature for data on the many variables which can affect design decisions in solar-heating applications, two of the most significant and obvious factors are:

1. The heating load on the building, as imposed on an hourly, daily, and long term basis.
2. The availability of solar energy, also as a function of short and long term time periods.

HEATING LOAD

In regard to heating load, a well documented and ample supply of data has been recorded for most localities. Degree-day maps are available from the U. S. Weather Bureau, plotting heating loads both monthly and annually. Finer details, both tabulated and computerized, are also becoming available from numerous stations, allowing a daily or hourly analysis of those climatic factors such as temperature, wind, and dewpoint, which determine heating demand. Although interpolation of this data for locations between recording stations can sometimes be unreliable in cases where geographic factors such as mountains, deserts, and large areas of water or vegetation affect the local microclimate, in general the existing data is adequate for regionalized studies of this climatic factor in the U. S.

SOLAR ENERGY—GEOGRAPHICAL

The characteristics of the solar energy available at different geographical locations which can be utilized to meet all or part of a building's heating demand is less well documented. About 100 stations in the U. S. and Canada record daily data such as % sunshine, cloud cover, and the daily total of combined direct and diffuse solar radiation. Among these stations, very few report data on solar input which separates the direct (shadow-casting) from the diffuse (sky radiation) component of the total energy received.

DIFFUSE RADIATION

Solar energy is transmitted to the earth as radiation. In traversing the earth's atmosphere the intensity of the direct rays becomes reduced in varying amounts through *absorption* by water vapor (and to a lesser extent by ozone and carbon dioxide), through *reflection* by dust and water droplets, and through *scattering* by air molecules. That part of the reflected and scattered radiation which reaches the earth is known as diffuse or sky radiation. On sunny days, the peak intensity of this radiation is in the blue portion of the spectrum and gives the sky its color. The total radiation reaching the surface of the earth is the sum of the direct and diffuse components.

EXISTING MAPS—INADEQUACIES

The commonly available insolation (solar energy) maps are prepared for monthly averages, and reflect the average daily total radiation falling on a horizontal surface during the month. Although such data is of value in gaining a general sense of where the total inputs are either high or low, it does not address the important differences in mode of arrival of the energy (direct or diffuse) or the average amounts of the direct solar input which can be utilized by collectors titled southward. Since the traditional instruments for solar energy measurement (pyronometers) are usually designed to be operated on a horizontal plane, all data is in reference to this ground plane, and therefore maps plotting the recorded solar information need rather elaborate transformations to become graphically indicative of actual energy collection potential.

Plate A (Page 12) illustrates typical geographic plotting of heating loads and solar input. Heating loads in degree days per month are shown as shaded zones which have been highly simplified for clarity in the vicinity of abrupt discontinuities in load, particularly in the mountainous regions of the West. Solar input, in monthly average of daily btu/sq. ft. on a *horizontal* surface, is illustrated by the heavy isolines, spaced at intervals of 200 btu/sq. ft./day.

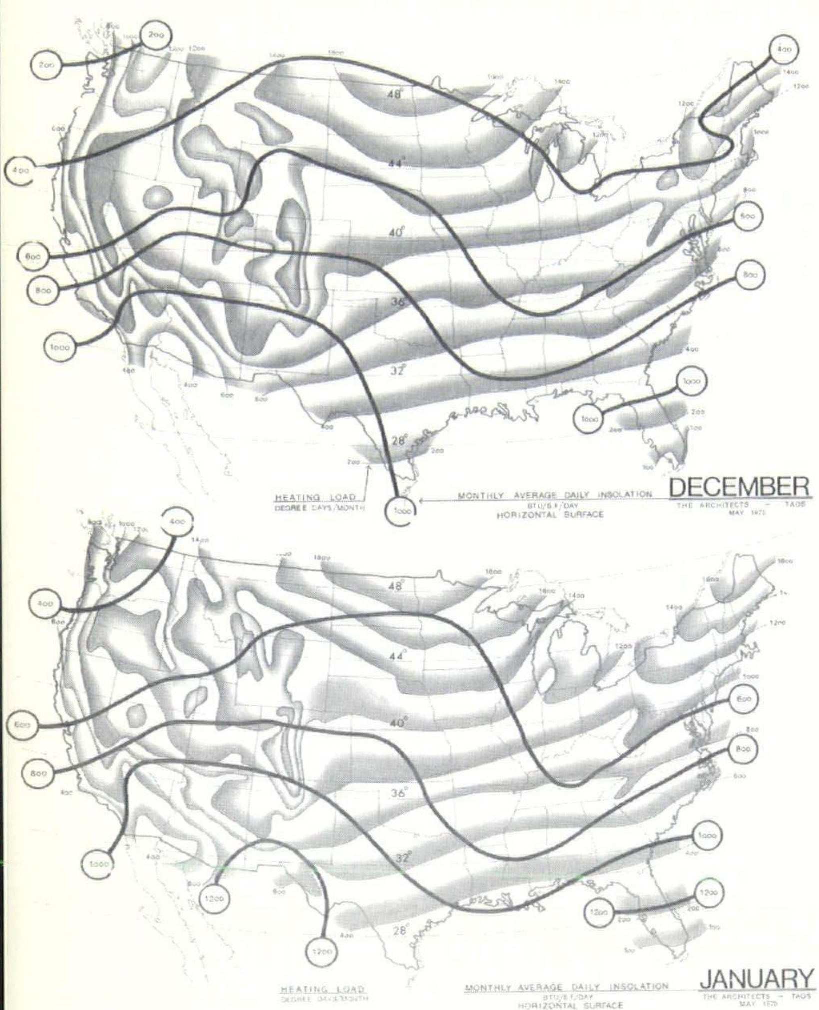


Plate A

In the month of December, we can see that the average daily total insolation on a horizontal surface in portions of the State of Washington is only one-fifth as great as in most of New Mexico and Arizona. Detroit receives the same average inputs as the northern tip of California. The monthly average for New York City is about half of that for Central Florida. As expected, solar input is reduced with increasing latitude, yet the Western States appear to enjoy about 25% more input than areas of equivalent latitude east of the Mississippi.

Although this type of insolation data, overplotted on heating load averages, is of obvious usefulness to the designer of solar heating systems, the specific characteristics of solar collector geometry cannot be optimized from the inspection of this data alone.

MAXIMIZING DIFFUSE

As mentioned earlier, important differences exist in the mode of arrival of the solar inputs. Diffuse radiation is generally best received on a horizontal plane, since by definition its origins are always from the entire hemisphere of the sky, whether cloudy or clear. Although the energy contribution of the diffuse component is substantially less than that of the direct component, its importance increases appreciably with the realization that it is often the *only* input during the coldest periods. Thus, if the relative percentage of wintertime diffuse is sufficiently high in a specific region, the plane of a solar collector may be oriented in favor of a horizontal position in order to achieve higher collection rates of *diffuse*. As a consequence of this low tilt angle, the ability of the collector to intercept *direct* winter sun would be reduced, because of the low altitudes of the winter sun. For example, the maximum solar altitude above the horizon at the winter solstice (December 22) varies, as a function of latitude, from a noon maximum of 20° in Minneapolis to 35° in El Paso.

Since information on solar input is presently available from most recording stations only in the form of *total* hourly and daily radiation received, a useful task is to illustrate a satisfactorily reliable method for estimating, at any given location, the separate percentages of the *diffuse* and *direct* components of solar input.

THE WORK OF LIU AND JORDAN

It is indeed fortunate that the literature contains invaluable and timely research on these and other aspects of solar radiation authored by Liu and Jordan in a series of papers published during the 1960's. Among other relationships developed in these co-authored works is a means of separating the *diffuse* and *direct* components at any given station when the *only* information available is the average *total* radiation received at the station. Although it is not appropriate in this report to retrace the ingenious process of development of these relationships, an interested reader is encouraged to refer to the Solar Energy Journal, July 1960, for detailed explanations of the following summary.

THE SOLAR CONSTANT

From experimental data, the intensity of solar energy arriving on a surface normal to the sun at the outer edge of the earth's atmosphere has been determined to average 442/btu hour/sq. ft., and this value is known as the Solar Constant. Seasonal variations of about 3½ percent occur due to eccentricity in the earth's orbit, and these variations can be accurately calculated, yielding a precise value for the intensity of this primary extra-atmospheric solar input at any given time of year.

THE SUNSHINE INDEX Kt

If, instead of being positioned at right angles to the sun's rays, an extra-atmospheric intercepting surface is parallel to the earth's surface above a given station, and therefore is tilted from the normal at

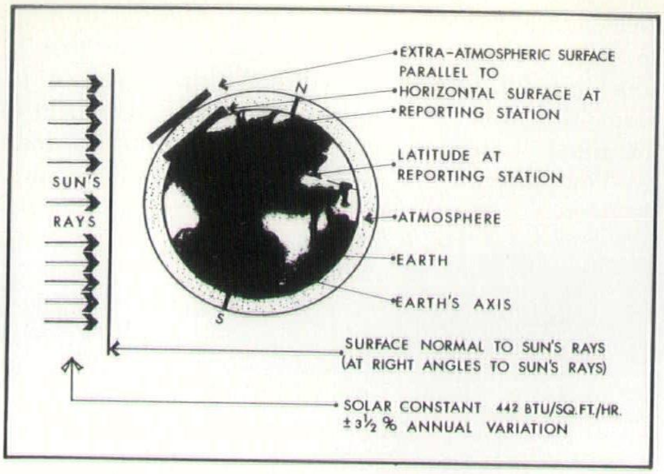


Fig. 1. Illustration of the theoretical extra-atmospheric surface on which H_o is calculated.

some angle (dependent on day of the year, time of day, and latitude of station) the resultant radiation intensity on the tilted surface will be reduced, and its value at any given angle of tilt can be calculated as a simple cosine function of the tilt angle. During any day, the sun's angle will continuously change in respect to a fixed intercepting surface, resulting in a corresponding change in energy input: zero at sunrise, increasing to maximum at solar noon, and subsiding back to zero at sunset. For a specific day, the total energy (H_o) incident on the extra-atmospheric surface parallel to the earth's surface can be calculated by integration, using the value of the solar constant and a trigonometric description of the sun's apparent path across the sky. A station on the earth located below this extra-atmospheric surface can also record the total daily radiation (H) falling on a horizontal plane at the station, and this data may be compared with the previously calculated amount of energy that would have fallen on the station if the atmosphere were not present. The comparison can be expressed either as a ratio, or (multiplying by 100), as a percentage of actual radiation received compared to the theoretical maximum falling on an atmosphereless station. This ratio of H/H_o, termed K_t, can be found for any place where pyronometers record the total daily or hourly solar energy.

Though Liu and Jordan refer to K_t as a "cloudiness index," actually the *higher* the fraction the *lower* is the actual cloud cover. The fraction is really an indication of the amount of total radiation that penetrates the atmosphere, and hence in this report K_t is referred to as the "sunshine index."

At those few stations equipped with instruments to record both diffuse (D) and total radiation (H) separately, another ratio, D/H, can also be obtained, and (multiplying by 100) may be expressed as the percentage of the daily diffuse radiation received compared to the daily total of both diffuse and direct.

By graphical analysis of recorded data from widely separated stations, Liu and Jordan discovered that a firm relationship exists between the ratio K_t and the ratio of D/H. A simplified graph of this relationship is illustrated in Figure 2. The highest plotted value of K_t (percent of the calculated "extra-atmospheric" that makes it through the sky to a recording pyronometer) is in the vicinity of 75%, which indicates that under total clear sky conditions, about 25% of the extra-atmospheric input is lost due to absorption or a return to space from scattering on the trip through the atmosphere. At this level of K_t, approximately 15% of the total energy received is contributed by the diffuse component.

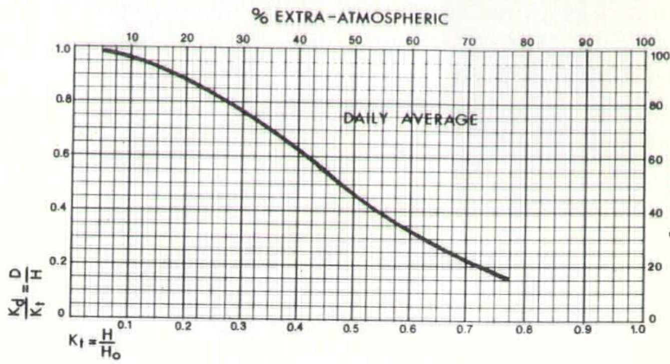


Fig. 2. The ratio of D/H, the daily *diffuse radiation to the daily total radiation, as a function of the sunshine index, K_t.*

At the upper end of the curve, where K_t is about 5% of total extra-atmospheric input, the contribution from diffuse is 100%. No direct sun is seen on a day of this type, and the total cloud cover required for this condition is very dense—possibly 4 or 5 miles deep. All other points on the curve represent various degrees of cloudiness or other atmospheric obscuration, each point establishing a definite ratio of D/H for a corresponding value of K_t. It is important to note that these relationships are not for just a *single* station, and *are not dependent on latitude* or other factors peculiar to a particular location. They apply with impressive accuracy over a broad geographical range—Alaska, Wake Island, Helsinki, London, Nice, and to stations in the continental United States which record the D/H ratio. Using this graph, both the daily *diffuse* and *direct* solar components can be estimated from a *single* recorded observation—the total daily insolation (H) received at any recording station.

Computations for any specific station and day are performed as follows:

1. Record H, the actual total energy received on a horizontal surface.
2. Compute H_o, the theoretical solar input for extra-atmospheric conditions.
3. Compute K_t, which is the ratio of H/H_o Express as percentage if desired.

4. From the graph in Fig. 1, find the ratio D/H which corresponds to K_t.
5. Compute D by multiplying the D/H ratio by the value of H obtained in step #1.
6. If desired, the daily direction radiation (H_d) may be found by subtracting D from H.

By this simple process the daily values of diffuse and direct may be established for any station which records the total daily solar radiation on a horizontal surface.

MONTHLY AVERAGES

A similar process may be used to obtain *monthly* averages for the daily data. Daily records may be averaged to give the monthly average daily total ($\overline{H}$), and the ratio $\overline{H}/\overline{H_o}$ then produces a monthly average value for $\overline{K_t}$. Using a new graph from Liu and Jordon, Figure 3, the ratio of average daily diffuse ($\overline{D}$) to average daily total ($\overline{H}$) for the month is found as a function of $\overline{K_t}$, and this yields $\overline{D}$ and the value of $\overline{H_d}$ in the same manner as in the case of the daily calculations.

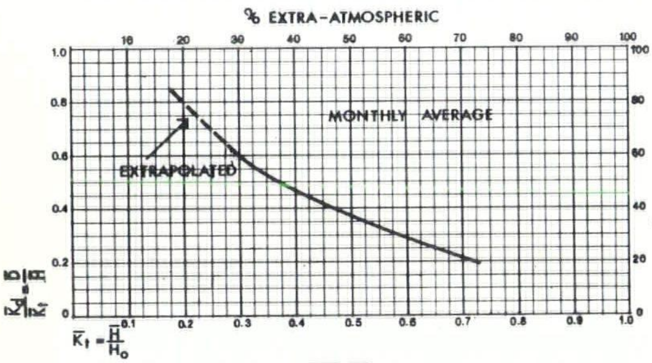


Fig. 3. The ratio of $\overline{D}/\overline{H}$, the monthly *average daily diffuse radiation to the monthly average daily total radiation, as a function of the sunshine index,* K_t.

Due to the variations in cloudiness which always occur during a monthly period, the graph for the *monthly* average daily ratios is limited to a narrower range of values than is the graph for daily values. With two exceptions, the experimental values of $\overline{K_t} \times 100$ for the U. S. fall within a range of 30 to 70. Seattle exceeds this limit at the cloudy end with a $\overline{K_t} \times 100$ of 27. At the opposite end, Albuquerque scores the highest for stations recording $\overline{H}$, with a $\overline{K_t} \times 100$ of 70.4%.

Having found a method for separating the monthly average daily diffuse and direct components, it is now possible to contemplate the preparation of maps which deal with each component separately. The data for diffuse on a horizontal surface is adequate as developed, since this component is most efficiently collected by a stationary *horizontal* collector. The direct, however, is preferably collected on a surface *normal* to the sun's rays, and except in the vicinity of the Equator, stationary flat plate collectors are customarily *tilted* as required by latitude to optimize collection efficiency during the seasonal periods desired. Fixed collectors designed to favor the direct component during winter months are tilted at various angles southward from horizontal. One common tilt angle is equal to latitude plus 20 degrees.

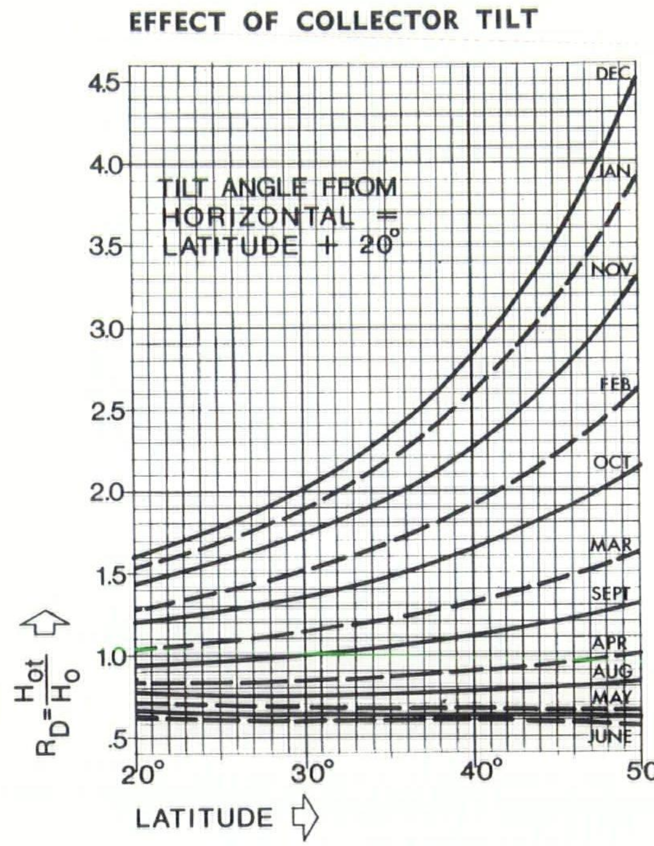


Fig. 4. Effect of tilting the collector to an angle of latitudè plus 20° for all months of the year, illustrated for latitudes beween 20° and 50°. R_d *is the ratio of* H_{ot}, *daily radiation on a surface tilted southward from the horizontal to Ho, daily radiation on a horizontal surface, under extra-atmospheric conditions.*

In order to compute the effect of such a tilt, the graph in Figure 4 was constructed from data developed by Liu and Jordan in 1967, and illustrates the ratio R_d as a function of latitude. Rd is the ratio of extra-atmospheric daily radiation on a surface tilted southward by an angle equal to latitude plus 20 degrees (H_{ot}), to daily radiation on a horizontal surface (H_o). The values of $R_d \times 100$ indicate the percentage change in average daily direct energy incident on a collecting surface as a consequence of the latitude + 20° tilt. Note that this increase is especially dramatic at the higher latitude in the winter months. At 50° north latitude in January, a surface tilted at latitude + 20° receives almost four times as much direct energy as the same surface in a

horizontal plane. In Albuquerque in December, the increase is 2.3 times the horizontal. From the graph it is also apparent that during summer months the tilt will cause losses. For a full six month period, at 20° latitude the tilted surface will intercept less direct incident energy than if the surface were horizontal (R_d less than 1.0).

In developing the data to plot maps for December and January, the graph was used to convert the value of $\overline{H}_d$ (monthly average daily direct radiation on a horizontal surface) to the average value of the same radiation on a south tilted surface ($\overline{H}_{dt}$), for each of 74 stations in the U. S. A typical December posting (below) for the first three stations provides interesting contrasts.

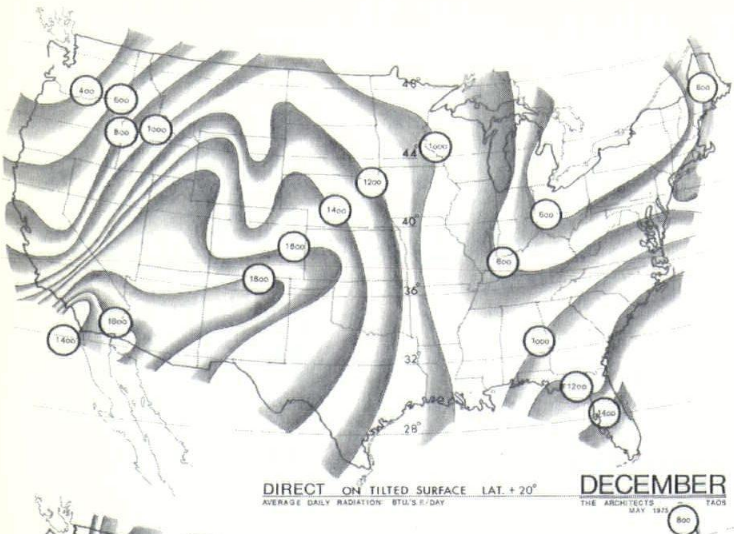
Note that although the measured radiation ($\overline{H}$) for Albuquerque and Apalachicola is very close, the value of $\overline{H}_{dt}$ develops a significant spread between these locations. Astoria receives only 28% of the $\overline{H}$ of Albuquerque, and 27% of the $\overline{H}_{dt}$. These two stations approximate the limits of variation in solar input in the continental United States, with Albuquerque receiving about four times the total of direct and diffuse as Astoria. This large range has clear implications on the cost effectiveness of solar energy systems in the U. S.

Tilt = latitude + 20°
— = monthly average daily
Month = December

	Albuquerque, New Mexico	Apalachicola, Florida	Astoria, Oregon	
North Latitude	35°03'	29°45'	46°12'	
$\overline{H}$ (measured radiation)	1051.6	982.3	295.2	btu/sf/day
$\overline{K}_t$ x 100 (% of extra-atmospheric)	70.4	54.3	33.2	percent
$\overline{D}/\overline{H}$ x 100 (% diffuse from graph)	21.0	34.0	53.0	percent
$\overline{D}$ (estimated diffuse H x D/H)	220	334	157	btu/sf/day
$\overline{H}_d$ (direct on horizontal surface)	831	648	137	btu/sf/day
R_d (tilt mulplier from graph)	2.32	1.94	3.66	
$\overline{H}_{dt}$ (direct on tilted surface)	1927	1257	502	btu/sf/day
$\overline{D}/\overline{H}_{dt}$ (ratio, diffuse to tilted direct)	.115	.266	.314	

Typical posting for first three stations in list of 74 used for plotting insolation maps. Values of H and Kt are from original Liu and Jordan calculations.

Continued Page 16



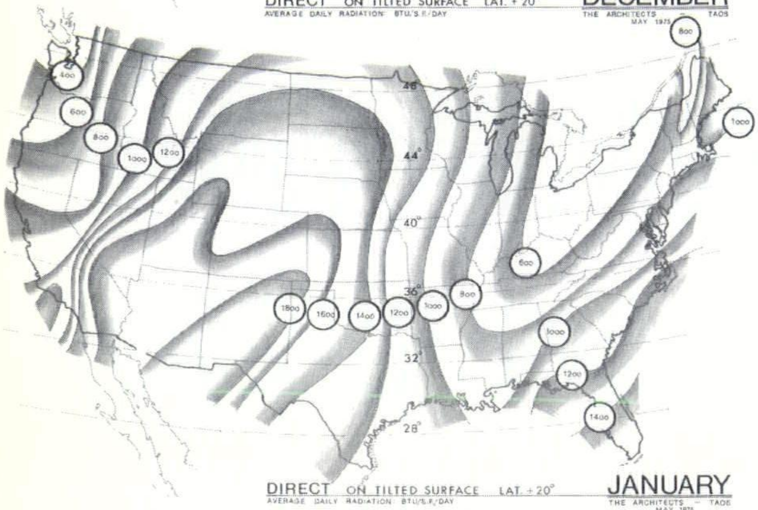


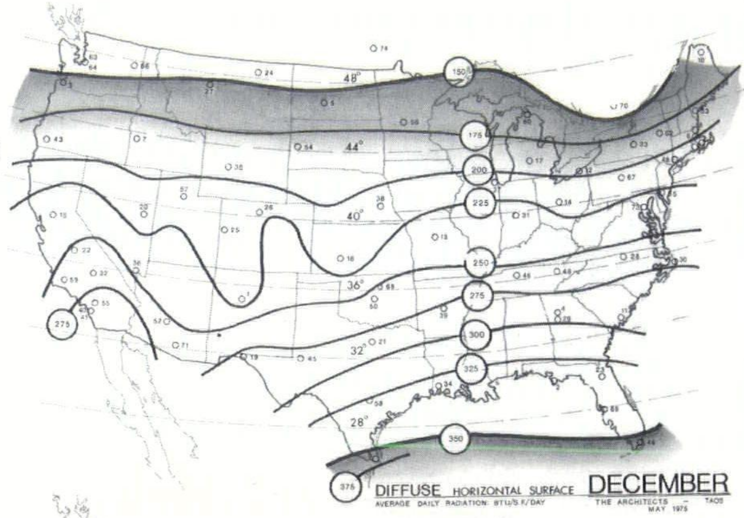
Plate B.

From data previously developed, it is now possible to compare geographic plots of btu/s.f./day of direct radiation on a tilted surface ($\overline{H}_{dt}$) and btu/s.f./day of diffuse radiation on a horizontal surface ($\overline{D}$) for the coldest months.

Examining the geographic behavior of $\overline{H}_{dt}$, we find severe alterations in the familiar isoline patterns typical to weather service plots of total daily radiation ($\overline{H}$) as measured horizontally. The effect of collector tilt can dramatically alter those assessments of solar energy availability made from plots of $\overline{H}$ alone. A surge of high input covers the Western States, with much of North Dakota and Montana (48° lat.) receiving more direct insolation than Washington, D.C. (39° lat.). An abrupt reduction occurs east of the states, bordering the Mississippi, deepening further into Ohio. The Northwest States are also very low, receiving only one-fourth of the input that falls into Arizona and New Mexico. California experiences an increase of 300% from its highest to its lowest latitudes.

In January, the December patterns intensify, with closely packed isolines running vertically through the midsection of the country. While the Western States enjoy a higher daily average of sunshine, states east of the Mississippi are sun-starved even more than in December, despite the overall increase in extra-atmospheric (H_0) in January.

It is perhaps well to note that there is nothing sacred about the tilt of "latitude + 20°". Any fixed tilt is at best a compromise between summer and winter collection conditions and actually a tilt of "latitude + 15°" is more commonly recommended. Data provided by Liu and Jordan was given only for tilts equal to "latitude" and "latitude + 20°". The latter was chosen for the maps in this report as it is judged to be the better of the two for winter collection of the direct component.



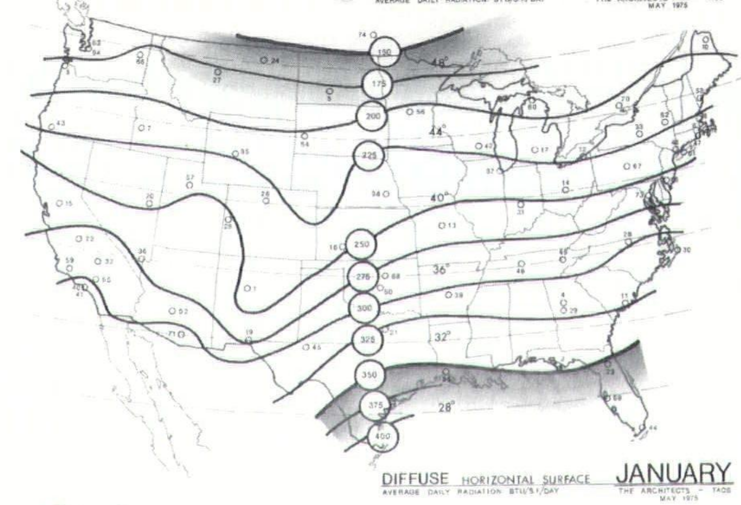
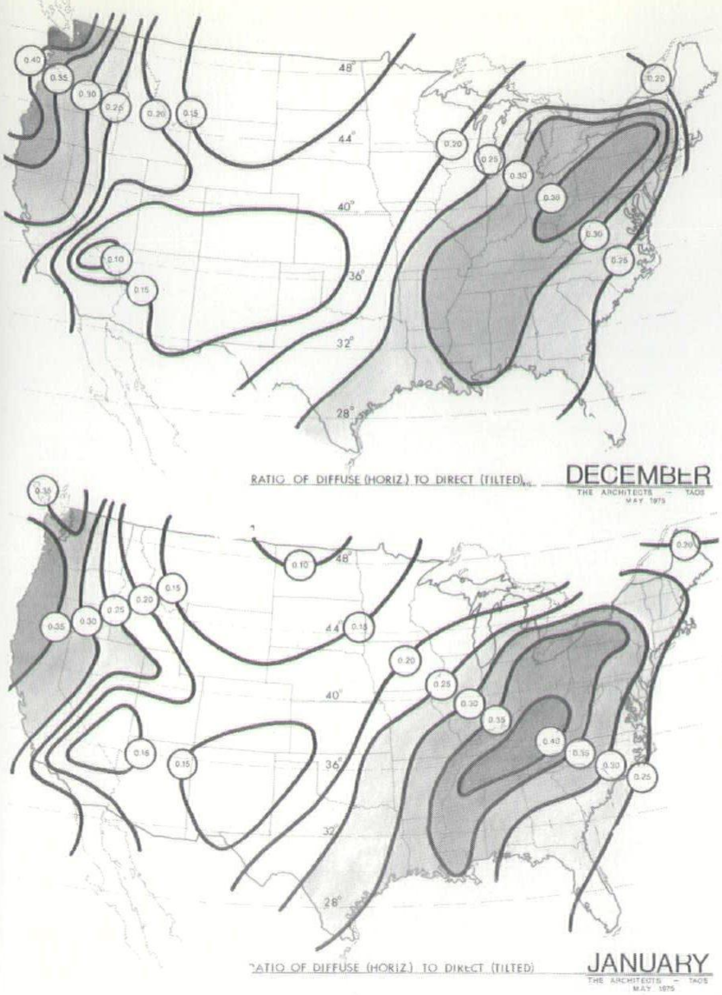


Plate C.

Plots of diffuse sky radiation appear primarily as quiescent functions of latitude. Except for the anomalous influences of the Western Mountains, the isolines are generally horizontal. From the Canadian Border the amount of diffuse more than doubles as the Gulf States are reached. From these maps, it seems that quantities of diffuse radiation as distributed geographically are NOT a significant function of cloudiness. Washington, D.C. does as well as Denver; murky Cleveland is close to Lander, Wyoming.



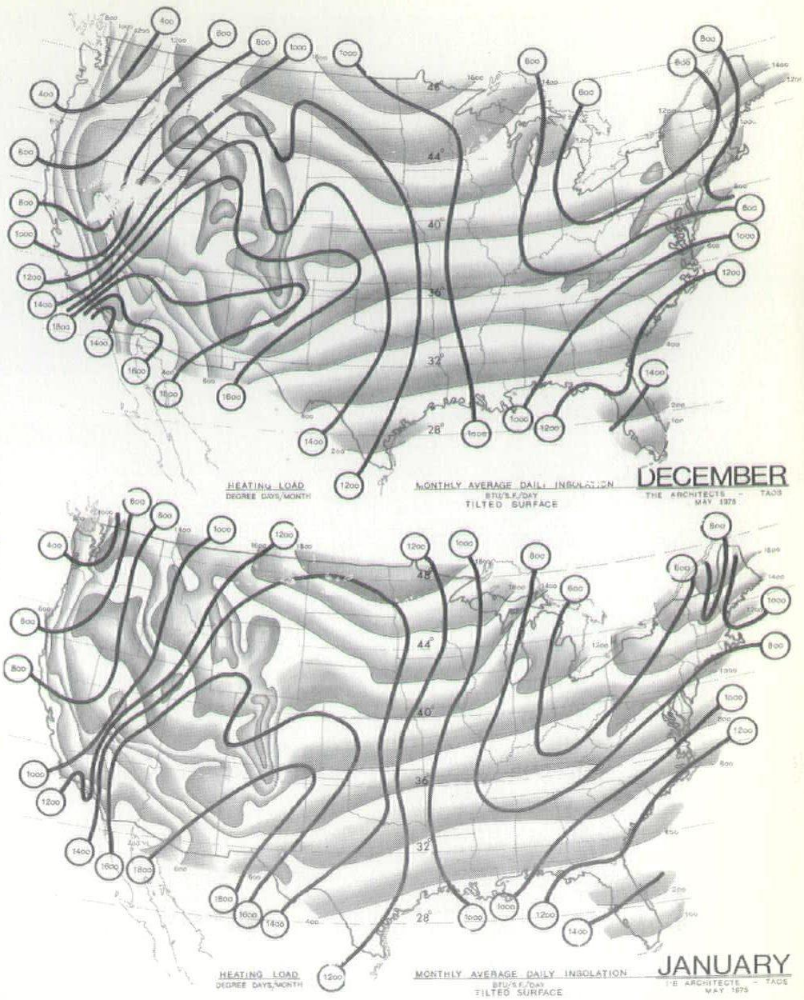


Plate D.

Although diffuse radiation ($\overline{D}$) appears to be primarily a function of latitude, the severe variations in direct on a tilted surface ($\overline{H}_{dt}$) which are weather-induced produce, in some areas, significant changes in the ratio of diffuse to direct. A geographic plot of this ratio, $\overline{D}/\overline{H}_{dt}$, reveals two regions in the United States where the diffuse component is of particular significance in collector selection and tilting. During December the middle Eastern States and those in the extreme northwest and portions of Northern California receive from 30 to 40 percent diffuse on a horizontal surface, compared to the input striking a tilted collector designed to optimize interception of the direct component. In these areas, all characterized by a low $\overline{K}_t$ the diffuse component is of high significance, and a trade-off is called for in the determination of collector tilt, especially in consideration of the inherent reliability of diffuse, which often becomes the only available input during periods of high heating demand.

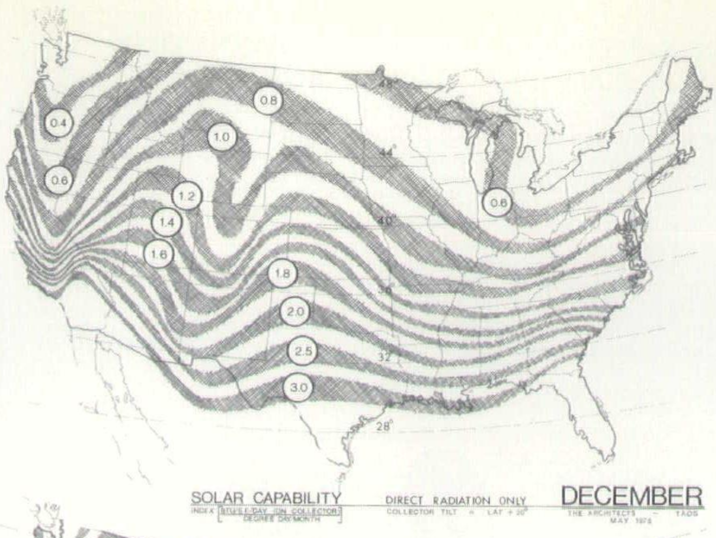
In the midwestern States, characterized by higher values of $\overline{K}_t$, the ratio of the diffuse component diminishes sufficiently in some regions so as to have only a marginal influence in optimizing the collector angle.

Plate E.

Using the direct insolation data for a tilted collector plotted on the previous plate, an over-plot of this data on a monthly degree-day demand map is useful in gaining a comparison of the available direct energy to the heating demand loads for the month. The solar inputs are in average btu per square foot per day, and the heating loads in degree days per month.

In general, the most cost effective applications for solar heating systems should occur in areas where solar insolation and heating demand are both high. Typical regions where this condition occurs are in the Dakotas, Montana and Wyoming, in the high altitude locations in southern regions of the Rocky Mountains, and in the mountainous sections of Southern California.

It should be noted that for clarity the map has been generalized, especially in regard to the degree-day zones. In areas of abrupt geographic changes, values of $\overline{H}$ also change abruptly, resulting in possible severe local variations from average plotted values. In such locations, local microclimates must be investigated as a precondition to design decisions for solar heating systems.



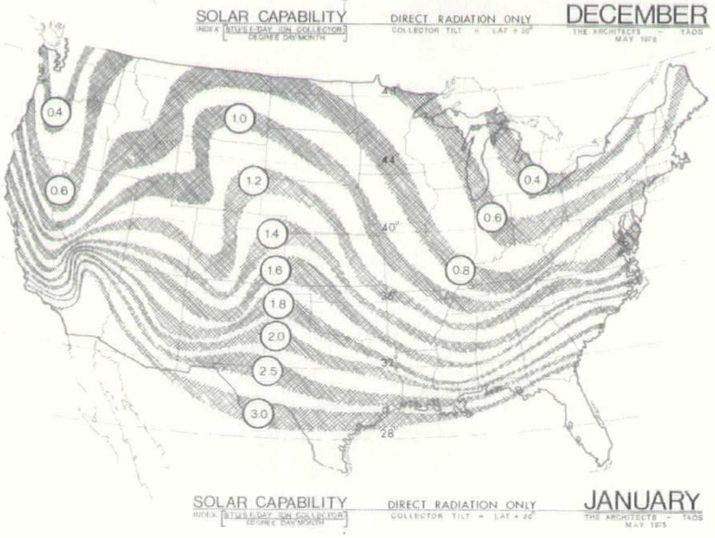


Plate F.

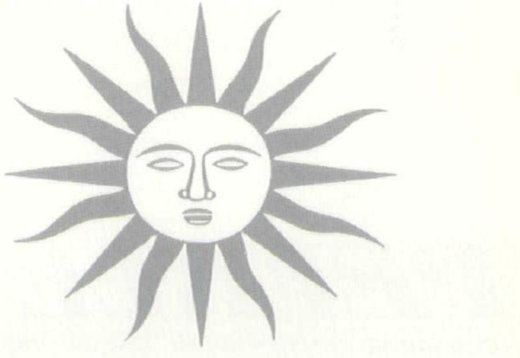
From data used on the previous plot of the $\overline{H}_{dt}$ *isolines, over-plotted on monthly degree day maps, a composite plot may be made, showing isolines of equal ratios of monthly direct insolation on a tilted surface to monthly degree day totals. In general terms, these isolines indicate equal monthly solar capability. Due to inadequate detail in the data available for plotting, the* $\overline{H}_{dt}$ *lines are widened into bands. The number on each band is a ratio of average btu/s.f./day direct energy falling on a tilted surface to the number of average degree days per month.*

Assuming a one month thermal storage capability for any given solar heating system, such a system could provide approximately the same percent of solar contribution to the transmission heating load of a building, using direct input only, at any point on a selected isoline.

Imagine a mobile dwelling of any size and appearance equipped with a solar-assisted heating system which utilizes a tilted collector and a one month storage capability. Suppose that, every year on December first, the dwelling is moved to a different location on a certain isoline of equal solar capability. After several years of such hectic relocations, records should indicate that, regardless of location on the isoline, the average % of December heating requirement contributed by the solar system is constant. The smaller changes in average solar input caused by $\overline{D}$, *the diffuse component which usually varies as a function of latitude, are not considered on these maps.*

Another comparison of general solar performance, (using only the direct component) can be made. Suppose that the mobile dwelling has been stationed at various points on the (0.8) isoline, and has averaged, say, 40% of its heating energy for a given month from direct solar input. Then if the dwelling was relocated to any point on an isoline of double value (1.6), the % solar contribution should also double, in this instance reaching 80%. Thus, the ratio between the numbers on any two isolines is an indication of the relative monthly performance of identical buildings located anywhere on the considered lines.

Thermal demands which are not direct functions of degree-day loads, such as water heating, are not considered in the development of these solar capability charts.



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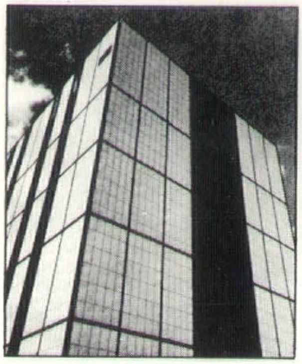

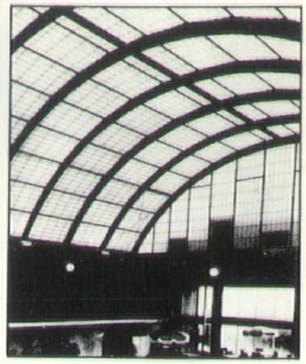

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